United Kingdom of Great Britain and Northern Ireland

EDICT OF GOVERNMENT

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BS NA EN 1997-1 (2004) (English): UK National Annex to Eurocode 7. Geotechnical design. General rules

Nulli vendemus, nulli negabimus aut differemus Rectum aut Justiciam.

We will sell to no man, we will not deny or defer to any man either Justice or Right.

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Part 1: General rules

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Corrigendum No. 1	31 December 2007	Reference in Table NA.1 8.6(4) changed to **A.8.6**, last word of **A.3.3.2** changed to "resistance" and Note A in Table A.NA.7 made same as Tables A.NA.6 and A.NA.8.

National Annex (informative) to BS EN 1997-1:2004, Eurocode 7: Geotechnical design – Part 1: General rules

Introduction

This National Annex has been prepared by BSI Technical Committee, B/526, *Geotechnics*. In the UK it is to be used in conjunction with BS EN 1997-1:2004 and BS EN 1990:2002.

NA.1 Scope

This National Annex gives:

a) the UK decisions for the Nationally Determined Parameters (see **NA.2**) described in the following subclauses in the body of BS EN 1997-1:2004:

2.1(8)P	**2.4.7.4**(3)P	**7.6.2.4**(4)P
2.4.6.1(4)P	**2.4.7.5**(2)P	**7.6.3.2**(2)P
2.4.6.2(2)P	**2.4.8**(2)	**7.6.3.2**(5)P
2.4.7.1(2)P	**2.4.9**(1)P	**7.6.3.3**(3)P
2.4.7.1(3)	**2.5**(1)	**7.6.3.3**(4)P
2.4.7.2(2)P	**7.6.2.2**(8)P	**7.6.3.3**(6)
2.4.7.3.2(3)P	**7.6.2.2**(14)P	**8.5.2**(2)P
2.4.7.3.3(2)P	**7.6.2.3**(4)P	**8.5.2**(3)
2.4.7.3.4.1(1)P	**7.6.2.3**(5)P	**8.6**(4)
		11.5.1(1)P

and the following subclauses in Annex A of BS EN 1997-1:2004:

– **A.2**

– **A.3.1**, **A.3.2**, **A.3.3.1**, **A.3.3.2**, **A.3.3.3**, **A.3.3.4**, **A.3.3.5**, **A.3.3.6**

– **A.4**

– **A.5**;

b) the procedure to be used where alternative procedures are given in BS EN 1997-1:2004 (see **NA.2** first paragraph);

c) the UK decisions on the status of BS EN 1997-1:2004 informative annexes (see **NA.3**); and

d) references to non-contradictory complementary information (see **NA.4**).

NA.2 Nationally Determined Parameters

National choice is permitted in the use of a Design Approach for the STR and GEO limit states (see BS EN 1997-1:2004, **2.4.7.3.4.1(1)P**). As indicated in Table NA.1, only Design Approach 1 is to be used in the UK.

Annex A of BS EN 1997-1:2004 lists the partial and correlation factors for ultimate limit states; the values of these factors are nationally determined parameters. Table NA.1 of this National Annex lists the clauses in BS EN 1997-1:2004 where national choice may be exercised in respect of factor values for design in the United Kingdom. Where choice applies, Table NA.1 indicates where values are given, or states a value to be used, or describes the procedure for specifying the factor. The values given in the Tables in Annex A of this National Annex replace the recommended values in Annex A of BS EN 1997-1:2004.

Where reference is made in BS EN 1997-1:2004 to the use of Annex A as a guide to the required levels of safety, this reference should be taken to mean Annex A of this National Annex.

BS EN 1997-1:2004 contains several references to "model factors" without making recommendations for the values to be used. Table NA.1 of this National Annex also lists these references. In some cases, values of the model factors are given in **A.6** of Annex A of this National Annex. Where no values are given, the values should be agreed, where appropriate, with the client and the relevant authorities. Subclauses **2.4.1**(8) and **2.4.1**(9) in BS EN 1997-1:2004 give guidance on how the values of such model factors should be selected. Model factors for pile design are given in **A.3.3.2** of Annex A of this National Annex.

Table NA.1 **Provisions of this National Annex related to Clauses in BS EN 1997-1:2004 where "national choice" is to be exercised**

Subclause	Feature	Provisions of this National Annex
2.1(8)P	Minimum requirements for light and simple structures and small earthworks.	Minimum requirements are not given in this National Annex and should be agreed where appropriate with the client and other relevant authorities.
2.4.6.1(4)P	The value of partial factor γ_F for persistent and transient situations.	Use the values given in **A.2.1** (EQU); **A.3.1** (STR/GEO); **A.4.1** (UPL) and **A.5** (HYD) in Annex A of this National Annex.
2.4.6.1(5)	Directly assessed design values for actions.	Where design values of actions are assessed directly the values of the partial factors for actions given in Annex A of this National Annex should be used as a guide to the required level of safety.
2.4.6.2(2)P	The value of partial factor γ_M for persistent and transient situations.	Use the values given in **A.2.2** (EQU); **A.3.2** (STR/GEO) and **A.4.2** (UPL) in Annex A of this National Annex.
2.4.6.2(3)	Directly assessed design values for geotechnical parameters.	Where design values of soil parameters are assessed directly, the values of the partial factors for soil parameters given in Annex A of this National Annex should be used as a guide to the required level of safety.
2.4.7.1(2)P	The values of partial factors to be used in persistent and transient situations.	Use the values given in the appropriate tables in Annex A of this National Annex.
2.4.7.1(3)	The value of partial factors to be used in accidental situations.	Take as equal to 1.0.

Table NA.1 **Provisions of this National Annex related to Clauses in BS EN 1997-1:2004 where "national choice" is to be exercised** (*continued*)

Subclause	Feature	Provisions of this National Annex
2.4.7.1(3)	The values of partial factors for resistance.	Use the values given in the appropriate tables in Annex A of this National Annex.
2.4.7.1(4)	The values of partial factors to be used in cases of abnormal risk or unusual or exceptionally difficult ground or loading conditions.	Values are not provided in this National Annex and should be agreed with the client and relevant authorities, where appropriate, for the specific situation.
2.4.7.1(5)	Reduced values of partial factors to be used for special situations for temporary structures or transient design situations, where the likely consequences justify it.	Values are not provided in this National Annex and might need to be agreed with the client and relevant authorities, for the specific situation.
2.4.7.1(6)	Values for model factors for resistance and the effects of actions.	See **A.6.1** to **A.6.6** of Annex A of this National Annex.
2.4.7.2(2)P	The values of partial factors to be used in persistent and transient situations for the EQU limit state.	Use the values given in **A.2** in Annex A of this National Annex.
2.4.7.3.2(3)P	The values of partial factors to be used in equations (2.6a) and (2.6b) of BS EN 1997-1:2004 for determining the design effects for STR and GEO limit states.	Use the values given in **A.3** in Annex A of this National Annex.
2.4.7.3.3(2)P	The values of partial factors to be used in equations (2.7a), (2.7b) and (2.7c) of BS EN 1997-1:2004 for determining the design resistances in the STR and GEO limit states.	Use the values given in **A.3.3.1**, **A.3.3.2**, **A.3.3.4**, **A.3.3.5** and **A.3.3.6** in Annex A of this National Annex.
2.4.7.3.4.1(1)P	The particular Design Approach to be used for the STR and GEO limit states.	Use Design Approach 1 only.
2.4.7.4(3)P	The values of partial factors for persistent and transient situations for the UPL limit state.	Use the values given in **A.4** in Annex A of this National Annex.
2.4.7.5(2)P	The values of partial factors for persistent and transient situations for the HYD limit state.	Use the values given in **A.5** in Annex A of this National Annex.
2.4.8(2)	The values of partial factors for serviceability limit states.	Take as equal to 1.0.
2.4.9(1)P	The amounts of permitted foundation movement.	Values are not provided in this National Annex. Advice is given on foundation movements for buildings in Annex H of BS EN 1997-1:2004.
2.5(1)	Conventional and generally conservative rules.	The use of prescriptive measures for design should be agreed, where appropriate, with the client and the relevant authorities. (see **2.1**(8) above).
7.6.2.2(8)P	The values of correlation factors ξ_1 and ξ_2.	Use the values given in **A.3.3.3** of Annex A of this National Annex.
7.6.2.2(14)P	The values of factors γ_b, γ_s and γ_t.	Use the values given in **A.3.3.2** of Annex A of this National Annex, depending on the type of pile.
7.6.2.3(4)P	The values of factors γ_b and γ_s.	Use the values given in **A.3.3.2** of Annex A of this National Annex, depending on the type of pile.
7.6.2.3(5)P	The values of correlation factors ξ_3 and ξ_4.	Use the values given in **A.3.3.3** of Annex A of this National Annex.
7.6.2.3(8)	The value of a corrective model factor for γ_b and γ_s.	Use the values given in **A.3.3.2** in Annex A of this National Annex.

Table NA.2 **Provisions of this National Annex related to Clauses in BS EN 1997-1:2004 where "national choice" is to be exercised** (*continued*)

Subclause	Feature	Provisions of this National Annex
7.6.2.4(4)P	The values of factors γ_t, ξ_5 and ξ_6.	For γ_t, use the values given in **A.3.3.2** of Annex A of this National Annex, depending on type of pile. For ξ_5 and ξ_6, use the values given in **A.3.3.3** of Annex A of this National Annex.
7.6.3.2(2)P	The value of factor $\gamma_{s;t}$.	For $\gamma_{s;t}$, use the values given in **A.3.3.2** of Annex A of this National Annex, depending on type of pile.
7.6.3.2(5)P	The values of correlation factors ξ_1 and ξ_2.	Use the values given in **A.3.3.3** of Annex A of this National Annex.
7.6.3.3(3)P	The value of factor $\gamma_{s;t}$.	For $\gamma_{s;t}$, use the values given in **A.3.3.2** of Annex A of this National Annex, depending on the type of pile.
7.6.3.3(4)P	The values of correlation factors ξ_3 and ξ_4.	Use the values given in **A.3.3.3** of Annex A of this National Annex.
7.6.3.3(6)	The value of a corrective model factor for $\gamma_{s;t}$.	Use the values given in **A.3.3.2** in Annex A of this National Annex.
8.5.2(2)P	The value of factor γ_a.	Use the values given in **A.3.3.4** of Annex A of this National Annex
8.5.2(3)	The value of correlation factor ξ_a for anchorages that are not individually checked by acceptance tests.	A value should be agreed, where appropriate, with the client and the relevant authorities.
8.6(4)	The value of the model factor to be applied to an anchorage force at SLS.	See **A.8.6** of Annex A of this National Annex.
11.5.1(1)P	The values of partial factors for stability analysis of slopes for persistent and transient design situations.	Use the values given in **A.3.1**, **A.3.2** and **A.3.3.6** in Annex A of this National Annex.

NA.3 Decisions on the status of informative annexes

NA.3.1 Annex B

BS EN 1997-1:2004, Annex B may be used.

BS EN 1997-1:2004, **B.1**(3), **B.1**(4) and **B.1**(5) and B.**2**(6) and B.**2**(7) relate to Design Approach 2 and 3 and are not therefore applicable to designs in the United Kingdom.

*NOTE Design resistances are expressed in three forms in BS EN 1997-1:2004, **2.4.7.3.3**, namely Equations (2.7a), (2.7b) and (2.7c). Equations (2.7a) and (2.7b) are simplifications of Equation (2.7c) for the specific cases where $\gamma_M = 1$ and $\gamma_R = 1$ respectively. The reference to Equation (2.7) in **B.3**(1) is strictly relevant to Equation (2.7c).*

NA.3.2 Annex C

BS EN 1997-1:2004, Annex C may be used.

Equations (C.1) and (C.2) do not include the effects of ground water – such effects should be considered when ground water is present.

The full equations are:

$$\sigma_a(z) = K_a [\int \gamma dz + q - u] + u - cK_{ac}$$

$$\sigma_p(z) = K_p [\int \gamma dz + q - u] + u + cK_{ac}$$

Where the integration is taken from ground surface to depth z and

u = pore water pressure at depth z

$K_{ac} = 2\sqrt{[K_a(1+a/c)]}$, limited to $2.56\sqrt{K_a}$

$K_{pc} = 2\sqrt{[K_p(1+a/c)]}$, limited to $2.56\sqrt{K_p}$

For drained soil, K_a and K_p are functions of angle of shearing resistance ϕ', and $c = c'$, the effective cohesion.

For undrained soil, $K_a = K_p = 1$ and $c = c_u$, the undrained shear strength.

The values of K_a and K_p given in Figures C.1.1 to C.1.4 and Figures C.2.1 to C.2.4 relate to vertical retained faces. Where the retained face is inclined, Equations (C.6) and (C.9) should be used. The note under Equation (C.9) says the expression is on the safe side; this can be taken to mean that it over-estimates the active pressure and under-estimates the passive pressure. When active pressure is favourable and passive pressure is unfavourable the results are therefore not on the safe side.

The values of K_a and K_p given in Figures C.1.1 to C.1.4 and Figures C.2.1 to C.2.4 are based on different theories from those on which Equations C.6 and C.9 are based. The two methods will therefore yield different results when δ is not equal to zero. The equations are more soundly based in theory but there is long experience of use of the graphs. They differ mainly for high values of φ and δ/φ for which it might be difficult to establish the reliability of the experience.

Figure C.3 is only illustrative and values of σ_p for V/v_p should not be read from this diagram. The value of V/h for any given value of K can be interpolated from Table C.2.

NA.3.3 Annex D

Annex D may be used. However, the sample method given in BS EN 1997-1:2004, Annex D omits depth and ground inclination factors which are commonly found in bearing resistance formulations. The omission of the depth factor errs on the side of safety, but the omission of the ground inclination factor does not. An alternative method to BS EN 1997-1:2004, Annex D, including the depth and ground inclinations as appropriate, may be used.

NA.3.4 Annex H

BS EN 1997-1:2004, Annex H may be used.

NOTE The limiting values of structural deformation and foundation movement relate primarily to buildings. Limiting values of structural deformation and foundation movement for other civil engineering works should be determined for the project and agreed, where appropriate, with the client and other relevant authorities.

NA.3.5 Other Annexes

BS EN 1997-1:2004, Annex E, Annex F, Annex G and Annex J may be used.

NA.4 References to non-contradictory complementary information

The following is a list of references that contain non-contradictory complementary information for use with BS EN 1997-1:2004.

- BS 1377;
- BS 5930;
- BS 6031;
- BS 8002;
- BS 8004;
- BS 8008;
- BS 8081;
- PD 6694-1 [1)];
- CIRIA C580 [1];
- UK Design Manual for Roads and Bridges [2].

Design aspects of some of these, or parts of them, might be in conflict with the design principles in BS EN 1997-1:2004. Until such time as "residual" documents are prepared to remove such conflicts and in the event that use of these documents presents a conflict, the Eurocode takes precedence.

EN 1997-1 Geotechnical Design does not cover the design and execution of reinforced soil structures. In the UK, the design and execution of reinforced fill structures and soil nailing should be carried out in accordance with BS 8006, BS EN 14475 and prEN 14490[1)]. The partial factors set out in BS 8006 should not be replaced by similar factors from Eurocode 7.

1) In preparation.

Bibliography

Standards publications

BS 1377 (all parts), *Methods of test for soils for civil engineering purposes*

BS 5930, *Code of practice for site investigations*

BS 6031, *Code of practice for earthworks*

BS 8002, *Code of practice for earth retaining structures*

BS 8004, *Code of practice for foundations*

BS 8006:1995, *Code of practice for Strengthened/reinforced soils and other fills*

BS 8008, *Safety precautions and procedures for the construction and descent of machine-bored shafts for piling and other purposes*

BS 8081, *Code of practice for ground anchorages*

BS EN 1990:2002, *Eurocode: Basis of structural design*

BS EN 1997-1:2004, *Eurocode 7: Geotechnical design – Part 1: General rules*

BS EN 14475, *Execution of special geotechnical work – Reinforced fill*

PD 6694-1, *Recommendations for the design of structures subject to traffic loading to BS EN 1997-1* [2)]

prEN 14490, *Execution of special geotechnical works – Soil nailing* [2)]

Other publications

[1] Gaba A. R. et al. C580 – *Embedded retaining walls – Guidance for economic design.* London: CIRIA, 2003. [3)]

[2] *UK Design Manual for Roads and Bridges*. London: The Stationery Office.

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2) In preparation.

3) CIRIA Classic House 174–180 Old Street London EC1V 9BP, U.K.

Annex A (informative) Design Approach and values of partial, correlation and model factors for ultimate limit states to be used in conjunction with BS EN 1997-1:2004

A.1 Nationally Determined Parameters

A.1.1 This Annex gives:

a) partial factors for geotechnical actions (γ_F) or the effects of geotechnical actions (γ_E) for ultimate limit states in the persistent and transient design situations;

b) partial factors for soil properties (γ_M) for ultimate limit states in the persistent and transient design situations;

c) partial factors for resistances (γ_R) for ultimate limit states in the persistent and transient design situations;

d) correlation factors (ξ) for pile foundations and anchorages in all design situations; and

e) advice on the use of model factors.

A.1.2 As stated in **NA.2**, paragraph 1, only Design Approach 1 is used in the UK for the STR and GEO limit states. This Annex therefore only provides partial factors appropriate for Design Approach 1. In applying Design Approach 1, the design resistance for both Combination 1 and Combination 2 can be found using Equation (2.7c) in BS EN 1997-1:2004. Equations (2.7a) and (2.7b) are simplified versions of Equation (2.7c) which can be used in situations where $\gamma_R = 1$ and $\gamma_M = 1$ respectively. For sliding, Equations (6.3a) and/or (6.4a) in BS EN 1997-1:2004 can be used for both Combination 1 and Combination 2. Equations (6.3a) and (6.4a) are simplified versions of the full expressions for sliding resistance for situations where $\gamma_{R;h} = 1$. The partial factors specified for permanent actions in this Annex have been established to be consistent with the principle that a single partial factor can be applied to permanent actions arising from a single source for the STR and GEO limit states (see Note to **2.4.2**(9)P of BS EN 1997-1:2004).

A.2 Partial factors for the equilibrium limit state (EQU) verification

A.2.1 Partial factors on actions (γ_F)

For the verification of the equilibrium limit state (EQU), the values of the partial factors on actions can be found in the National Annex to BS EN 1990:2002, using Table NA.A1.2(A) (Set A) for buildings and Table NA.A2.4(A) (Set A) for bridges. The terms $\gamma_{G;sup}$ and $\gamma_{G;inf}$ in BS EN 1990:2002 correspond with $\gamma_{G;dst}$ and $\gamma_{G;stb}$ in BS EN 1997-1:2004. Table A.NA.1 below shows the appropriate tables in BS EN 1990:2002.

In cases where overturning instability of a structure could occur without the resistance of the ground being exceeded the partial factors specified in the National Annex to BS EN 1990:2002 can give an overall factor of safety on overturning lower than that from which confidence has been gained through past UK practice. In such cases it is recommended that consideration be given to the use of higher partial factors.

The partial factors specified in the National Annex to BS EN 1990:2002 might not be appropriate for self-weight of water, ground-water pressure and other actions dependent on the level of water, see **2.4.7.3.2**(2). The design value of such actions may be directly assessed in accordance with **2.4.6.1**(2)P and **2.4.6.1**(6)P of BS EN 1997-1:2004. Alternatively, a safety margin may be applied to the characteristic water level, see **2.4.6.1**(8) of BS EN 1997-1:2004.

The design value of earth pressures should be based on the design value of the actions giving rise to the earth pressure. For bridge design, in some cases, additional model factors might be required when evaluating horizontal earth pressures (see **A.6.3** of this National Annex).

Actions listed in BS EN 1997-1:2004, **2.4.2** for which no values are set in BS EN 1991 may be specified for a particular project. The values of these actions and their partial factors and combination factors should be agreed with the client and relevant authorities.

Table A.NA.1 **Partial factors on Actions (γ_F) for the equilibrium (EQU) limit state**

Structure	Value
Buildings	See Table NA.A1.2(A) in the National Annex to BS EN 1990:2002
Bridges	See Table NA.A2.4(A) in the National Annex to BS EN 1990:2002

A.2.2 Partial factors for soil parameters (γ_M)

For the verification of the equilibrium limit state (EQU) the values of the partial factors on soil parameters should be taken from Table A.NA.2.

Table A.NA.2 **Partial factors for soil parameters (γ_M) for the EQU limit state**

Soil parameter	Symbol	Value
Angle of shearing resistance[A)]	$\gamma_{\varphi'}$	1.1
Effective cohesion	$\gamma_{c'}$	1.1
Undrained shear strength	γ_{cu}	1.2
Unconfined strength	γ_{qu}	1.2

[A)] Applied to tan φ' and tan φ'_{cv}, although it might be more appropriate to determine the design value of φ'_{cv} directly

*NOTE The value of the partial factor should be taken as the reciprocal of the specified value if such a reciprocal value produces a more onerous effect than the specified value (but see also the Note to **2.4.2**(9)P of BS EN 1997-1:2004).*

A.3 Partial factors for structural (STR) and geotechnical (GEO) limit states verification

A.3.1 Partial factors on actions (γ_F) or the effects of actions (γ_E)

Table A.NA.3 **Partial factors on actions (γ_F) or the effects of actions (γ_E) for the structural (STR) and geotechnical (GEO) limit states**

Structure type	Value	
	Set A1	**Set A2**
Buildings	See Table NA.A1.2(B) in the National Annex to BS EN 1990:2002	See Table NA.A1.2(C) in the National Annex to BS EN 1990:2002
Bridges	See Table NA.A2.4(B) in the National Annex to BS EN 1990:2002	See Table NA.A2.4(C) in the National Annex to BS EN 1990:2002

The partial factors specified in the National Annex to BS EN 1990:2002 might not be appropriate for self-weight of water, ground-water pressure and other actions dependent on the level of water, see **2.4.7.3.2**(2). The design value of such actions may be directly assessed in accordance with **2.4.6.1**(2)P and **2.4.6.1**(6)P of BS EN 1997-1:2004. Alternatively, a safety margin may be applied to the characteristic water level, see **2.4.6.1**(8) of BS EN 1997-1:2004.

The design value of earth pressures should be based on the design value of the actions giving rise to the earth pressure. For bridge design, in some cases, additional model factors might be required when evaluating horizontal earth pressures, see **A.6.3** of this National Annex.

Actions listed in BS EN 1997-1:2004 **2.4.2** for which no values are set in BS EN 1991 may be specified for a particular project. The values of these actions and their partial factors and combination factors might need to be agreed with the client and relevant authorities.

A.3.2 Partial factors for soil parameters (γ_M)

For the verification of the structural (STR) and geotechnical (GEO) limit states, the values of the partial factors on soil parameters should be taken from Table A.NA.4.

Table A.NA.4 **Partial factors for soil parameters (γ_M) for the STR and GEO limit state**

Soil parameter	Symbol	Set	
		M1	M2
Angle of shearing resistance[A)]	$\gamma_{\varphi'}$	1.0	1.25
Effective cohesion	$\gamma_{c'}$	1.0	1.25
Undrained shear strength	γ_{cu}	1.0	1.4
Unconfined strength	γ_{qu}	1.0	1.4

A) Applied to tan φ' and tan φ'_{cv}, although it might be more appropriate to determine the design value of φ'_{cv} directly.

*NOTE The value of the partial factor should be taken as the reciprocal of the specified value if such a reciprocal value produces a more onerous effect than the specified value (but see also the Note to **2.4.2**(9)P in BS EN 1997-1:2004).*

A.3.3 Partial resistance factors (γ_R)

A.3.3.1 Partial resistance factors for spread foundations

For the verifications of the structural (STR) and geotechnical (GEO) limit states the values of the partial factors $\gamma_{R;v}$ on bearing resistance and $\gamma_{R;h}$ on sliding resistance should be as given in Table A.NA.5.

Table A.NA.5 **Partial resistance factors (γ_R) for spread footings for the STR and GEO limit states**

Resistance	Symbol	Set R1
Bearing	$\gamma_{R;v}$	1.0
Sliding	$\gamma_{R;h}$	1.0

A.3.3.2 Partial resistance factors for pile foundations

The values of factors provided here are considered to be generally applicable for pile foundations. However, variation of these factors is permitted in particular circumstances when justified by thorough consideration and documented experience, and after being agreed, where appropriate, with the client and other relevant authorities.

For verifications of the structural (STR) and geotechnical (GEO) limit states of pile foundations, the values of the partial factors on resistance (γ_R) should be those given in Table A.NA.6, Table A.NA.7 and Table A.NA.8. These values are used to convert characteristic resistances to design values for ultimate limit state calculations. They apply irrespective of the process by which the characteristic resistances are derived.

Characteristic resistances may be derived from static load tests using EN1997-1 **7.6.2.2** (**7.6.3.2** for tensile loading), or from ground test results using EN1997-1 Equations 7.8 or 7.9 (7.17 or 7.18 for tensile loading). When the approach of Equations 7.9 or 7.18 is used to derive the characteristic resistances, a model factor should be applied to the shaft and base resistance calculated using characteristic values of soil properties by a method complying with EN1997-1, **2.4.1**(6). The value of the model factor should be 1.4, except that it may be reduced to 1.2 if the resistance is verified by a maintained load test taken to the calculated, unfactored ultimate resistance.

Table A.NA.6 **Partial resistance factors (γ_R) for driven piles for the STR and GEO limit states**

Resistance	Symbol	Set		
		R1	R4 without explicit verification of SLS[A)]	R4 with explicit verification of SLS[A)]
Base	γ_b	1.0	1.7	1.5
Shaft (compression)	γ_s	1.0	1.5	1.3
Total/combined (compression)	γ_t	1.0	1.7	1.5
Shaft in tension	$\gamma_{s;t}$	1.0	2.0	1.7

A) The lower γ-values in R4 may be adopted (a) if serviceability is verified by load tests (preliminary and/or working) carried out on more than 1% of the constructed piles to loads not less than 1.5 times the representative load for which they are designed, or (b) if settlement is explicitly predicted by a means no less reliable than in (a), or (c) if settlement at the serviceability limit state is of no concern.

Table A.NA.7 **Partial resistance factors (γ_R) for bored piles for the STR and GEO limit states**

Resistance	Symbol	Set		
		R1	R4 without explicit verification of SLS[A)]	R4 with explicit verification of SLS[A)]
Base	γ_b	1.0	2.0	1.7
Shaft (compression)	γ_s	1.0	1.6	1.4
Total/combined (compression)	γ_t	1.0	2.0	1.7
Shaft in tension	$\gamma_{s;t}$	1.0	2.0	1.7

A) The lower γ-values in R4 may be adopted (a) if serviceability is verified by load tests (preliminary and/or working) carried out on more than 1% of the constructed piles to loads not less than 1.5 times the representative load for which they are designed, or (b) if settlement is explicitly predicted by a means no less reliable than in (a), or (c) if settlement at the serviceability limit state is of no concern.

Table A.NA.8 **Partial resistance factors (γ_R) for continuous flight auger CFA piles for the STR and GEO limit states**

Resistance	Symbol	Set		
		R1	R4 without explicit verification of SLS[A)]	R4 with explicit verification of SLS[A)]
Base	γ_b	1.0	2.0	1.7
Shaft (compression)	γ_s	1.0	1.6	1.4
Total/combined (compression)	γ_t	1.0	2.0	1.7
Shaft in tension	$\gamma_{s;t}$	1.0	2.0	1.7

A) The lower γ-values in R4 may be adopted (a) if serviceability is verified by load tests (preliminary and/or working) carried out on more than 1% of the constructed piles to loads not less than 1.5 times the representative load for which they are designed, or (b) if settlement is explicitly predicted by a means no less reliable than in (a), or (c) if settlement at the serviceability limit state is of no concern.

A.3.3.3 Correlation factors for pile foundations

For the verifications of Structural (STR) and Geotechnical (GEO) limit states, the following correlation factors ξ should be applied to derive the characteristic resistance of axially loaded piles:

ξ_1 on the mean values of the measured resistances in static load tests;

ξ_2 on the minimum value of the measured resistances in static load tests;

ξ_3 on the mean values of the calculated resistances from ground test results;

ξ_4 on the minimum value of the calculated resistances from ground test results;

ξ_5 on the mean values of the measured resistances in dynamic load tests;

ξ_6 on the minimum value of the measured resistances in dynamic load tests.

Table A.NA.9, Table A.NA.10 and Table A.NA.11 give the correlation factor values.

Table A.NA.9 **Correlation factors (ξ) to derive characteristic values of the resistance of axially loaded piles from static pile load tests (n – number of tested piles)**

ξ for n =	1	2	3	4	$\geqslant 5$
ξ_1	1.55	1.47	1.42	1.38	1.35
ξ_2	1.55	1.35	1.23	1.15	1.08

*NOTE For structures having sufficient stiffness and strength to transfer loads from "weak" to "strong" piles, values of ξ_1 and ξ_2 may be divided by 1.1, provided that ξ_1 is never less than 1.0, see EN 1997-1 **7.6.2.2**(9).*

Table A.NA.10 **Correlation factors (ξ) to derive characteristic values of the resistance of axially loaded piles from ground test results (n – the number of profiles of tests)**

ξ for n =	1	2	3	4	5	7	10
ξ_3	1.55	1.47	1.42	1.38	1.36	1.33	1.30
ξ_4	1.55	1.39	1.33	1.29	1.26	1.20	1.15

*NOTE For structures having sufficient stiffness and strength to transfer loads from "weak" to "strong" piles, values of ξ_3 and ξ_4 may be divided by 1.1, provided that ξ_3 is never less than 1.0, see EN 1997-1 **7.6.2.3**(7).*

Table A.NA.11 **Correlation factors (ξ) to derive characteristic values of the resistance of axially loaded piles from dynamic impact tests (where n is the number of tested piles)**

ξ for n =	$\geqslant 2$	$\geqslant 5$	$\geqslant 10$	$\geqslant 15$	$\geqslant 20$
ξ_5	1.94	1.85	1.83	1.82	1.81
ξ_6	1.90	1.76	1.70	1.67	1.66

NOTE 1 The ξ-values may be multiplied with a model factor of 0.85 when using dynamic impact tests with signal matching.

NOTE 2 The ξ-values should be multiplied with a model factor of 1.10 when using a pile driving formula with measurement of the quasi-elastic pile head displacement during the impact.

NOTE 3 The ξ-values should be multiplied with a model factor of 1.20 when using a pile driving formula without measurement of the quasi-elastic pile head displacement during the impact.

NOTE 4 If different piles exist in the foundation, groups of similar piles should be considered separately when selecting the number n of test piles.

A.3.3.4 Partial resistance factors (γ_R) for pre-stressed anchorages

For pre-stressed anchorages and verifications of the structural (STR) and geotechnical (GEO) limit states, the partial factors to be applied on resistance (γ_R) should be as given in Table A.NA.12.

Table A.NA.12 **Partial resistance factors for pre-stressed anchorages at the STR and GEO limit states**

Resistance	Symbol	Set	
		R1	R4
Temporary	$\gamma_{a;t}$	1.1	1.1
Permanent	$\gamma_{a;p}$	1.1	1.1

*NOTE Larger values of $_R$ should be used for non-prestressed anchorages, to make their designs consistent with those of tension piles (**A.3.3.2** and **A.3.3.3**) or retaining structures (**A.3.3.5**), as appropriate.*

A.3.3.5 Partial resistance factors (γ_R) for retaining structures

For retaining structures and verifications of the structural (STR) and geotechnical (GEO) limit states, the partial factors to be applied on resistance (γ_R) should be as given in Table A.NA.13.

Table A.NA.13 **Partial resistance factors for retaining structures at the STR and GEO limit states**

Resistance	Symbol	Set R1
Bearing capacity	$\gamma_{R;v}$	1.0
Sliding resistance	$\gamma_{R;h}$	1.0
Earth resistance	$\gamma_{R;e}$	1.0

A.3.3.6 Partial resistance factors (γ_R) for slopes and overall stability

For slopes and overall stability verifications of the structural (STR) and geotechnical (GEO) limit states, the partial factors to be applied on ground resistance ($\gamma_{R;e}$) should be as given in Table A.NA.14.

Table A.NA.14 **Partial resistance factors for slopes and overall stability at the STR and GEO limit states**

Resistance	Symbol	Set R1
Earth resistance	$\gamma_{R;e}$	1.0

A.4 Partial Factors for the uplift limit state (UPL) verification

A.4.1 Partial factors on actions (γ_F)

For the verification of the uplift limit state (UPL) the values for the partial factors on actions (γ_F) should be as given in Table A.NA.15.

Table A.NA.15 **Partial factors on actions (γ_F) at the UPL limit states**

Action	Symbol	Value
Permanent		
Unfavourable[A)]	$\gamma_{G;dst}$	1.1
Favourable[B)]	$\gamma_{G;stb}$	0.9
Variable		
Unfavourable[A)]	$\gamma_{Q;dst}$	1.5
Favourable[B)]	$\gamma_{Q;stb}$	0

A) Destabilizing
B) Stabilizing

*NOTE The partial factor specified for permanent unfavourable actions does not account for uncertainty in the level of ground water or free water. In cases where the verification of the UPL limit state is sensitive to the level of ground water or free water, the design value of uplift due to water pressure may be directly assessed in accordance with **2.4.6.1**(2)P and **2.4.6.1**(6)P of BS EN 1997-1:2004. Alternatively, a safety margin may be applied to the characteristic water level, see **2.4.6.1**(8) of BS EN 1997-1:2004.*

A.4.2 Partial factors on soil parameters (γ_M) and resistances (γ_R)

For the verification of the uplift limit state (UPL) the partial factors on soil parameters should be as given in Table A.NA.16.

Table A.NA.16 **Partial factors for soil parameters (γ_M) and resistances (γ_R) at the uplift (UPL) limit state**

Soil parameter	Symbol	Value
Angle of shearing resistance[A)]	$\gamma_{\varphi'}$	1.25
Effective cohesion	$\gamma_{c'}$	1.25
Undrained shear strength	γ_{cu}	1.4

Resistance	Symbol	Value
Tensile pile resistance	$\gamma_{s;t}$	See Note 2
Anchorage	γ_a	1.4 [B)]

A) Applied to tan φ' and tan φ'_{cv}, although it might be more appropriate to determine the design value of φ'_{cv} directly.

B) Larger values of γ_R should be used for non-prestressed anchorages, to make their designs consistent with those of tension piles (**A.3.3.2** and **A.3.3.3**) or retaining structures (**A.3.3.5**), as appropriate.

*NOTE 1 The value of the partial factor for soil parameters should be taken as the reciprocal of the specified value if such a reciprocal value produces a more onerous effect than the specified value (but see also the Note to **2.4.2**(9)P in BS EN 1997-1:2004).*

*NOTE 2 Pile design should comply with clauses **A.3.3.2** and **A.3.3.3**.*

A.5 Partial Factors for actions for the Hydraulic Heave limit state (HYD) verification

For the verification of the Hydraulic Heave limit state (HYD) the partial factors on actions (γ_F) are as given in Table A.NA.17.

Table A.NA.17 **Partial factors on actions (γ_F) at the Hydraulic Heave (HYD) limit state**

Action	Symbol	Value
Permanent		
Unfavourable[A)]	$\gamma_{G;dst}$	1.335
Favourable[B)]	$\gamma_{G;stb}$	0.9
Variable		
Unfavourable[A)]	$\gamma_{Q;dst}$	1.5
Favourable[B)]	$\gamma_{Q;stb}$	0

A) Destabilizing

B) Stabilizing

*NOTE In applying the specified partial factors in Equation (2.9a) of BS EN 1997-1:2004, the hydrostatic component of the destabilizing total pore water pressure ($u_{dst;d}$) and the stabilizing total vertical stress ($\sigma_{stb;d}$) can be considered to arise from a single source, see Note to **2.4.2**(9)P in BS EN 1997-1:2004.*

A.6 Model Factors

A.6.1 BS EN 1997-1:2004, **2.4.7.1**(6) states that model factors may be applied to the design value of a resistance or the effect of an action to ensure that the results of the design calculation model are either accurate or err on the safe side.

A.6.2 For buildings designed using conventional calculation methods, it can be assumed that the necessary model factors are incorporated in the partial factors given in this Appendix except as specified in **A.6.5** to **A.6.6**.

A.6.3 For bridges and other structures subject to highway loading, an additional model factor may be introduced for the evaluation of the earth pressure coefficient K, see PD 6694-1.

A.6.4 Additionally, where the method of analysis of a building or a bridge is innovative, or where the results of a calculation are of uncertain reliability, model factors may be applied. In such cases the values should be agreed with the client and relevant authorities. In selecting the values of a model factor, the principles described in BS EN 1997-1:2004, **2.4.1**(8) and **2.4.1**(9) should be applied.

A.6.5 Model factors required in pile design are provided in **A.3.3.2** and **A.3.3.3**.

A.6.6 BS EN 1997-1:2004, **8.6**(4) requires a model factor to be applied to the SLS value of an anchorage force to ensure that the resistance of the anchorage is sufficiently safe. The meaning of this paragraph is being questioned with the Eurocode 7 Maintenance Group. Until clarification is received, no value for the model factor is recommended by this National Annex.

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